

ATD Report 66-38

4 April 1966

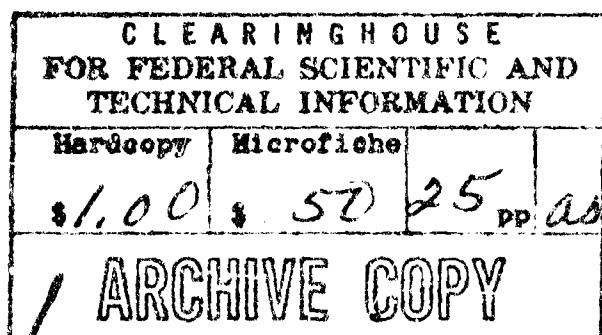
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LIQUID-METAL EMBRITTLEMENT

Annotated Bibliography

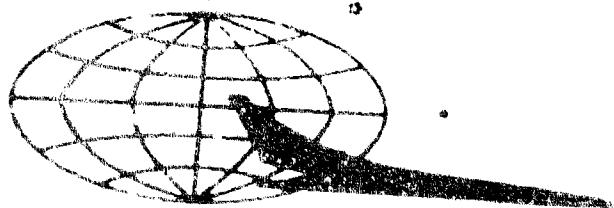
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IFRIS INDEX CONTROL FORM II

01--ACCESSION NO.:	71--FID "T" NUMBER:	68--DRAFT NUMBER:	69--PROJECT NUMBER:
		ATI-16-38	6010201
72--TYPE OF PROJ.:	74--SUBMITTING ORG.:	75--DATE OF PROJECT:	76--DATE SUBMITTED:
Task	TDEWA	01JUL65	
79--TITLE: Liquid-metal embrittlement			
82--AUTHOR: ATD			
89--TOPIC TAGS: liquid metal, carbon steel, brittleness, solid mechanical property, rupture strength, deformation rate, zinc, metal, mercury, material deformation, single crystal, steel, corrosion, sodium, irradiation, mechanical heat treatment			55--CONTRACT NO.: 72202
			86--NUMBER OF PAGES:
73--DATE PUBL.:	47--SUBJECT: Materials; Physics		
78--CHANGES:		77--SUPERSEDES:	76--REEL AND FRAME NO.:
83--SECURITY and DOWNGRADING INFORMATION:		64--RELEASABILITY:	40--GEOGRAPHICAL AREA:
Unclassified		No Restrictions Contractor Disclaimer	USSR
70--INITIAL DISSEMINATION:			

ABSTRACT

This annotated bibliography was compiled from Soviet open sources published 1959-1965 with one entry from January 1966. It is the first report in this series. The 52 entries are arranged chronologically and, within each year, alphabetically by author: 1959 (1 entry), 1961 (6 entries), 1962 (6 entries), 1963 (21 entries), 1964 (3 entries), 1965 (14 entries), and 1966 (1 entry). An author index is provided at the end of the report. Pertinent information included: copper alloy testing in mercury salt solution, creep process, diffusion and solubility coefficients of molten metals, polycrystalline metal, tin recrystallization, alloy steel nonselective corrosion, surface tension reduction in solid metals, softening action of aggressive melts on solid metal, steel cyclic torsion in low-melting metals, adsorption-induced reduction of strength, irradiation effect on mechanical properties, anisotropy of electron and gamma irradiation effect on deformation process, metal corrosion fatigue, effect of low melting coating on mechanical properties of metals, metal diffusion in liquid copper.

Surveys of Soviet Scientific and Technical Literature

LIQUID-METAL EMBRITTLEMENT

Annotated Bibliography

ATD Work Assignment No. 89/b
(Report No. 1 in this series)

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FOREWORD

This annotated bibliography is based on Soviet open-source publications available at the Aerospace Technology Division and the Library of Congress and covers the period 1959—January 1966. The entries are arranged chronologically and alphabetically by author within each year. An author index is provided at the end of the report.

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LIQUID-METAL EMBRITTLEMENT

A. 1959

1. Andreyev, P. A., A. A. Kanayev, and Ye. D. Fedorovich. Behavior of steels in liquid metals. IN: Zhidko-metallicheskiye teplonositeli yadernykh reaktorov (Liquid-metal heat conductors in atomic reactors). Leningrad, Sudpromgiz, 1959. 356-359. TK9203.F5K3

The authors review the results of the first Soviet investigation (1938-1940 and 1955) of the effect of mercury, lead, bismuth, and their eutectic alloys on carbon and alloy steels.

B. 1961

2. Bryukhanova, L. S., I. A. Andreyeva, and V. I. Likhtman. The effect of surface-active metallic melts on the rupture strength of metals. Fizika tverdogo tela, v. 3, no. 9, 1961, 2774-2778. QC176.AlF5

The effect of mercury and gallium amalgams on the rupture strength of polycrystalline zinc and cadmium specimens 1 mm in diameter and 10 mm long has been studied. Zinc specimens coated with a 5- μ mercury film broke down instantly under a stress of 1 kg/mm², but remained intact infinitely under 0.96 kg/mm². Cadmium specimens coated with a 5- μ gallium film broke down under 2.7 kg/mm², but remained intact under 2.4 kg/mm².

3. Chayevskiy, M. I., and V. I. Likhtman. Effect of the deformation rate on the strength and ductility of carbon steel in contact with low-melting metals. IN: Akademiya nauk SSSR. Doklady, v. 140, no. 5, 1961, 1054-1057. AS262.S3663

Specimens of carbon steels 20, 35, 45, and 50 [AISI: C 1020, C 1035, C 1045, and C 1050] coated with lead-bismuth or lead-tin eutectics were subjected to tensile and impact tests at 300-600°C. It was found that molten metals have a detrimental effect on the

strength and ductility of the steels only at medium rates of deformation. At very low (0.055 mm/min) or very high (impact test) deformation rates, molten metals improve both strength and ductility.

4. Ivanov, V. F., and Z. A. Iofa. Formation of amalgams by iron-group metals in a mercury-drop electrode. IN: Akademiya nauk SSSR. Doklady, v. 140, no. 6, 1961, 1368-1371.

An attempt has been made to clarify the behavior of metals reduced by mercury, depending on the conditions of the cathodic process. Findings showed that metals deposited at low cathodic polarization, such as Fe, Ni, or Co, dissolve anodically at potentials more negative than those of mercury dissolution. At first, solid Fe, Ni, or Co microcrystals are formed during electrodeposition on a mercury-drop electrode, independently of the polarization value.

5. Likhtman, V. I., L. S. Bryukhanova, and I. A. Andreyeva. Rupture strength of metals. IN: Akademiya nauk SSSR. Doklady, v. 139, no. 2, 1961, 359-362.

Stress-rupture tests at 20-100°C with zinc single crystals and polycrystalline zinc, and cadmium coated with mercury (zinc) or gallium (cadmium) showed no definite dependence between the rupture life and stress. All specimens either failed instantly under a certain relatively low stress (about 0.9 kg/mm² for zinc and 2.8 kg/mm² for cadmium) or remained intact indefinitely under a slightly lower stress.

6. Summ, B. D., Yu. V. Goryunov, N. V. Pertsov, and Ye. D. Shchukin. Spreading of mercury on a zinc surface and the adsorption-induced reduction of strength. IN: Akademiya nauk SSSR. Doklady, v. 137, no. 6, 1961, 1413-1415.

The spreading of mercury on the surface of unstressed 98.7%-pure zinc plate and 99.99%-pure zinc wire at room temperature has been investigated. It was confirmed that mercury spreads by two different mechanisms: surface migration and volume diffusion.

7. Summ, B. D., Yu. V. Goryunov, N. V. Pertsov, Ye. D. Shchukin, and P. A. Rebinder (Academician). Crack formation in a zinc plate, locally coated with mercury, during bend tests. IN: Akademiya nauk SSSR. Doklady, v. 136, no. 6, 1961, 1392-1395.

The propagation of rupture cracks in 98.7%-pure commercial zinc plates 0.8-3.0 mm thick, on which a drop of mercury (0.2-4 μ g) was deposited, has been investigated. The zinc plates were subjected for 5-10 min to bend tests under a load which produced a tension stress of 7-8 kg/mm². As a result, cracks appeared at the point of contact between zinc and mercury. The cracks propagated rapidly in the direction perpendicular to stress.

C. 1962

8. Chayevskiy, M. I. Effect of low-melting metals on the stress state in the surface layer of cyclic-deformed steel. IN: Akademiya nauk SSSR. Doklady, v. 142, no. 6, 1962, 1294-1297.

Some liquid low-melting metals in contact with steel specimens being subjected to cyclic deformation create compression stresses in the surface layers of the specimens. Tin or lead-tin alloy form an intermetallic compound which fills surface defects created by cyclic stresses and increases fatigue strength. The lead-bismuth eutectic, however, does not react with iron, but is surface active toward it; this reduces the energy of defect formation and thus lowers the fatigue strength.

9. Chayevskiy, M. I., L. S. Bryukhanova, and V. I. Likhtman. Rupture strength of steel in active-metal melts. IN: Akademiya nauk SSSR. Doklady, v. 143, no. 21, 1962, 92-94.

The rupture strength of steel 50 (SAE-1050) in liquid lead-tin or zinc-tin eutectics (50% tin) or tin-copper (5% copper) at 400°C has been investigated. All three media were found to lower sharply the rupture life of steel, especially at high stresses (over 40 kg/mm² for lead-tin and zinc-tin eutectics). At lower stresses the effect of lead-tin eutectic is beneficial.

10. Goryunov, Yu. V., N. V. Pertsov, B. D. Sutin, and Ye. D. Shchukin. The effect of microrelief on the spreading of liquid metal over the surface of solid metal. In: Akademiya nauk SSSR. Doklady, v. 146, no. 3, 1962, 638-641.

Mercury spreading on an oxide-free surface of polycrystalline zinc has been studied. It was found that, depending on the microrelief of the surface, the liquid metal either flows along the surface or diffuses in the surface.

11. Likhtman, V. I., Ye. D. Shchukin, and P. A. Rebinder. Fiziko-khimicheskaya mekhanika metallov (physico-chemical mechanics of metals). Moskva, Izd-vo AN SSSR, 1962. 304 p.

The book reviews results of research on the adsorption effect, which reduces metal strength and facilitates metal deformation. Part II of this book discusses the effect of small quantities of adsorption-active liquid metals on the process of deformation and fracture of metals, e.g., embrittlement of metals in liquid-metal media (mercury) and reduction in strength and ductility of metal single crystals in liquid Sn, SnPb alloy, Hg, and Ga. The plasticizing effect of molten metallic coatings, changes in the mechanical properties and structure of tin single crystals under the effect of liquid gallium, and the effect of mercury and gallium on the rupture strength of solid metals are also discussed.

12. Nikitin, V. I. Rupture strength of steel in liquid sodium contaminated with oxygen. Fizika metallov i metallovedeniye, v. 14, no. 4, 1962, 613-617.

TN690.F53

An austenitic steel containing 13.6% Cr, 18.9% Ni, 2.3% W, 1.2% Nb was subjected to stress-rupture tests at 700°C in air or in liquid sodium containing 0.01 or 0.25% oxygen. It was found that liquid sodium with 0.25% oxygen shortens the rupture life and increases the creep rate compared to those in air.

13. Troitskiy, O. A., and V. I. Likhtman. Combined action of β -radiation and an active medium on the mechanical properties of zinc single crystals. IN: Akademiya nauk SSSR. Doklady, v. 147, no. 4, 1962, 874-877.

The effect of β -radiation on the mechanical properties of zinc single crystals 1 mm in diameter coated with a 5- μ mercury film was studied. β -active P^{32} isotope was used as the radiation source. It was found that irradiation increases the tensile strength at the liquid-nitrogen temperature and improves ductility at both room temperature and liquid-nitrogen temperature.

D. 1963

14. Chayevskiy, M. I. The effect of adsorption-induced plasticizing on the mechanical properties of metals, and accompanying phenomena. IN: Akademiya nauk UkrSSR. Institut mashinovedeniya i avtomatiki. Sbornik. Vliyaniye rabochikh sred na svoystva materialov (Effect of working media on material properties), no. 2, 1963, 7-23.

Analysis of the experimental data confirms that adsorption-induced plasticizing of metals is a primary process and can be accompanied by strengthening, or softening, or brittle failure. Three methods are suggested to reduce or eliminate the negative effects of surface active environments: 1) thermomechanical treatment, which would reduce or prevent the diffusion of molten metals in steel; 2) modification of the chemical composition of steel and molten metal, which will result in a formation of protective layer on steel surface; and 3) creating conditions of deformation which, in combination with precautions mentioned under 2, would permit a relaxation of local stresses and maintain the activation energy of diffusion on a level sufficiently high to prevent the diffusion of molten metal atoms in steel.

15. Chayevskiy, M. I., and V. F. Shatinskij. Effect of molten Al-Sn-Pb alloy on the strength characteristics of 20 Kh steel. IN: Akademiya nauk UkrSSR. Institut mashinovedeniya i avtomatiki. Sbornik. Vliyaniye rabochikh sred na svoystva materialov (Effect of working media on material properties), no. 2, 1963, 40-47.

An attempt has been made to reduce the detrimental effect of molten Sn-Pb alloy on steel strength by adding aluminum to molten alloy. Tests with 20 Kh steel [SAE-1020] showed that aluminum forms a protective layer on the steel surface which significantly improves the tensile strength and ductility of steel at temperatures up to 600°C and the fatigue strength at temperatures up to 400°C.

16. Chayevskiy, M. I., V. F. Shatinskiy, and V. V. Popovich. Thermomechanical treatment of machine parts as protection against softening in active media. IN: Akademiya nauk SSSR. Doklady, v. 152, no. 5, 1963, 1096-1099.

Thermomechanical treatment of stress concentrators in machine parts, i.e., austenitizing, cooling to 400 to 600°C, and plastic deformation at the points of stress concentration, produces a structure which is stable in some surface-active melts. Results of tests of 40 Kh steel (AISI-5140) specimens in Pb-Sn eutectic are reviewed.

17. Dykova, G. P., and V. I. Nikitin. Effect of liquid sodium on the rupture strength of structural materials. IN: Sbornik statey. Zhidkiye metally (Liquid metals). Moskva, Gosatomizdat, 1963. 292-299. QC320.B57

Stress-rupture and creep tests of EI-851 steel were conducted at 700°C, EI-869 alloy at 750°C, and EI-437B alloy at 800°C in liquid sodium and in air. It was found that liquid sodium affected neither the rupture strength nor the creep of EI-851 steel and EI-869 alloy. However, it lowered the rupture strength and ductility and increased the creep rate in EI-437B alloy in all three creep stages.

18. Gavze, M. N., and N. T. Gudtsov. Vozdeystviye rtuti kak teplonositelya na stal' v energeticheskikh ustankakh (Effect of a mercury heat carrier on steel used at power plants), 2nd ed. Moskva, Izd-vo AN SSSR, 1963. 240 p.

The book reviews cases in which mercury is used as a heat carrier and the interaction of mercury and its vapors with steel at high temperatures and pressures. Data on the interaction of mercury with other metals are also presented.

19. Gladyshev, V. P. Some physicochemical properties of the binary metal-mercury system. *Fizika metallov i metallovedeniye*, v. 15, no. 2, 1963, 203-209.

The type of phase diagram for the binary metal-mercury system is determined by the structure of the d-shell of the metal atom. Metals with an unoccupied d-shell form systems with intermetallic compounds, while metals with fully occupied d-shells do not form any intermetallic compounds with mercury and are characterized by a smooth liquidus line connecting the melting points of compounds. Metals with partially occupied d-shells are fully insoluble in mercury.

20. Goryunov, Yu. V., and B. D. Summ. Diffusion of mercury and gallium on a zinc surface and adsorption-induced reduction of metal strength. *Fizika metallov i metallovedeniye*, v. 16, no. 2, 1963, 209-216.

The mechanism of the spreading of mercury and gallium along an oxide-free surface of polycrystalline zinc has been investigated. It was found that the extent of spreading is determined by the diffusion of liquid metal into zinc. Mercury spreads primarily by surface diffusion. Gallium diffuses into the solid metal along the grain boundaries. The final diameter of the spot formed by a spreading drop of liquid metal increases with increasing mass of the drop and increasing temperature.

21. Goryunov, Yu. V., B. D. Summ, Ye. D. Shchukin, and P. A. Rebinder (Academician). The role of kinetic factors in the adsorption-induced reduction of metal strength. IN: *Akademiya nauk SSSR. Doklady*, v. 153, no. 3, 1963, 634-637.

The authors show that the spreading of adsorption-active metals on a stressed solid metal surface usually occurs by diffusion. In some cases, however, it can occur by capillary action. The rate of spreading determines the deformation rate at which the generation and propagation of cracks takes place.

22. Maksimovich, G. G., and S. V. Nagirnyy. Effect of active liquid media on the tensile and fatigue strength of prestrained microspecimens. IN: Akademiya nauk UkrSSR. Institut mashinovedeniya i avtomatiki. Sbornik. Vliyaniye rabochikh sred na svoystva materialov (Effect of working media on material properties), no. 2, 1963, 102-107.

L-62 brass specimens, 1.0 mm in diameter, were prestrained by up to 40% elongation and subjected to tensile tests in mercury. The effect of mercury on the strength and ductility of prestrained specimens was found to be roughly the same as that of initial (not prestrained) specimens. Mercury lowers both strength and ductility.

23. Maksimovich, G. G., and F. P. Yanchishin. Rupture strength of cast iron and brass in liquid media. IN: Akademiya nauk UkrSSR. Institut mashinovedeniya i avtomatiki. Sbornik. Vliyaniye rabochikh sred na svoystva materialov (Effect of working media on material properties), no. 2, 1963, 97-101.

At a rupture life of 4320 hr, the rupture strength of brass coated with mercury dropped by 63%. The results for cast iron are not shown.

24. Nikitin, V. I. Adsorption-induced effect of liquid metal on the deformation process of solid metal. Fizika metallov i metallovedeniye, v. 15, no. 6, 1963, 900-907.

Nickel-base EI-437B alloy [AISI-Nimonic 80A] was subjected to stress-rupture tests at 800°C in air and liquid sodium. Liquid sodium was found to effect primarily the rate of the first stage creep. The relative effect of liquid sodium is higher at lower stresses.

25. Nikitin, V. I. Process of corrosion in liquid metals under isothermal and non-isothermal conditions. Zhurnal prikladnoy khimii, v. 36, no. 10, 1963, 2192-2201. TPI.Z63

The corrosion process in liquid metals under isothermal and non-isothermal conditions has been studied. The corrosion under isothermal conditions was gradually stopped but the non-isothermal corrosion process

was characterized by a constant corrosion rate. Both processes depend on the dissolution rate and saturation concentration.

26. Nikitin, V. I. Effect of liquid sodium on the stress relaxation in steel. IN: Sbornik statey. Zhidkiye metally (Liquid metals). Moskva, Gosatomizdat, 1963. 300-306. QC320.B57

Relaxation of EI-853 steel (annealed at 860°C) in sodium at 600°C with an initial stress of 16, 14, and 9 kg/mm² was studied. It was found that liquid metal accelerated the relaxation process under all the stresses tested. The accelerating effect increases with increasing initial stress.

27. Novokreshchenov, P. D., and N. V. Savchenko. The effect of low melting coating on the mechanical properties of metals after cyclic heat-treatment. IN: Akademiya nauk SSSR. Doklady, v. 148, no. 2, 1963, 328-331.

The effect of low-melting metal coatings such as tin, bismuth, lead, zinc, cadmium, and PCS-40 alloy on the mechanical properties of nickel, copper, brass, and phosphorous bronze subjected to cyclic heat treatment at various temperatures has been investigated. It was found that the change in mechanical properties depends on the number of cycles and atmosphere (air or argon). The grain size of coated specimens was always less than that of uncoated specimens.

28. Shurygin, P. M., and V. D. Shantarin. Diffusion of metals in liquid copper. Fizika metallov i metallovedeniye, v. 16, no. 5, 1963, 731-736.

The diffusion kinetics and diffusion rate of silicon, titanium, chromium, iron, cobalt, and nickel in liquid copper have been studied. Diffusion coefficients were found to be 10^{-5} — 10^{-6} cm²/sec at 1373°K for all the metals tested.

29. Stepurenko, V. T. Conference on metal corrosion fatigue.
IN: Akademiya nauk UkrSSR. Dopovidi, no. 2, 1963,
274-276. Q60.A7

At a conference held in Lvov at the Department of Technical Sciences, Ukrainian Academy of Sciences, 27-29 November 1962, problems of corrosion fatigue of metals were discussed. M. I. Chayevskiy, Candidate of Technical Sciences, presented a report on the "Effect of the state of the surface layer on the fatigue strength of steel in contact with liquid low-melting metals."

30. Troitskiy, O. A., P. Ya. Glazunov, and V. I. Likhtman. The effect of electron irradiation on the strength of zinc coated with low-melting eutectics. Fizika metallov i metallovedeniye, v. 15, no. 4, 1963, 534-537.

The effect of electron irradiation on polycrystalline zinc coated with Zn-Sn, Zn-Cd, and Zn-Pb eutectics has been investigated at 20, 200—220, and -196°C. Irradiation was found to increase the strength of zinc by 40% at all the temperatures tested.

31. Troitskiy, O. A., I. M. Kuleshov, and V. I. Likhtman. The effect of radioactivity and mercury on the mechanical properties of zinc single crystals. Fizika metallov i metallovedeniye, v. 16, no. 1, 1963, 44-50.

The effect of α - β and γ -irradiation isotopes of Pu^{239} , P^{32} , and Co^{60} , respectively, on the mechanical properties of zinc single crystals coated with mercury film has been studied. It was found that irradiation alone (without mercury) and short (up to about 20 hr) irradiation of mercury-coated specimens intensifies the relaxation and increases the ductility in the process of stepwise deformation without load. Prolonged (1400—1500 hr) irradiation of mercury-coated specimens sharply decreases the strength and ductility owing to a coagulation of radiation-induced defects and the formation of new interfaces. Migration of mercury to these interfaces lowers the free surface energy of metals.

32. Troitskiy, O. A., and V. I. Likhtman. The effect of mercury and irradiation on the mechanical properties of zinc single crystals. IN: Akademiya nauk SSSR. Doklady, v. 149, no. 5, 1963, 1115-1118.

[See abstract no. 31 (Troitskiy, O. A., I. M. Kuleshov, and V. I. Likhtman. The effect of radioactivity and mercury on the mechanical properties of zinc single crystals. Fizika metallov i metallovedeniye, v. 16, no. 1, 1963, 44-50).]

33. Troitskiy, O. A., and V. I. Likhtman. Anisotropy of the effect of electron and γ -irradiation on the process of deformation of zinc single crystals in the brittle state. IN: Akademiya nauk SSSR. Doklady, v. 148, no. 2, 1963, 332-334.

Specimens of zinc single crystals, 1 mm in diameter coated with a 5- μ thick layer of mercury, were subjected to tensile tests either with simultaneous electron or γ -irradiation or after being subjected to irradiation. It was found that irradiation brings about an additional drop in strength and ductility, but only when the direction of radiation is perpendicular to the bases plane of the single crystals. With the direction of radiation parallel to the bases plane, ductility increases.

34. Yanchishin, F. P. Effect of mercury on the strength of lead. IN: Akademiya nauk UkrSSR. Institut mashinovedeniya i avtomatiki. Sbornik. Vliyaniye rabochikh sred na svoystva materialov (Effect of working media on material properties), no. 2, 1963, 53-55.

Tests showed that mercury reduced the strength of 99.9%-pure lead by 20%, the elongation by 10%, the reduction of area by 80%, and the true strength by 86%.

E. 1964

35. Chayevskiy, M. I., and V. F. Shatinskiy. Cyclic torsion of steel in low-melting metals. IN: Akademiya nauk UkrSSR. Fiziko-mekhanicheskiy institut. Sbornik. Vliyaniye rabochikh sred na svoystva materialov (Effect of working media on material properties), no. 3, 1964, 92-99.

The fatigue behavior of 50 steel (AISI-1050) in molten alloy containing 59.5% tin, 36.7% lead, and 3.8% aluminum was studied by cyclic bending and torsion tests. Test results show that the molten alloy forms with steel intermetallic compounds, which fill the defects in the steel surface and thus improve the performance of steel.

36. Flegontova, N. I., B. D. Summ, and Yu. V. Gorgunov. The effect of previous contact of liquid with solid metals on the adsorption-induced reduction of strength. Fizika metallov i metallovedeniye, v. 18, no. 5, 1964, 724-729.

The effect of a previous contact of polycrystalline zinc with mercury or gallium has been studied. It was found that the strength of zinc is reduced by holding in liquid metals in proportion to the conditions and duration of holding.

37. Troitskiy, O. A., and I. G. Berzina. Effect of irradiation on the mechanical properties of zinc single crystals in the presence of surface-active metal melts. Fizika metallov i metallovedeniye, v. 18, no. 1, 1964, 125-131.

The effect of irradiation on the mechanical properties of zinc single crystals coated with a layer of mercury has been studied. It was found that prolonged proton and neutron irradiation sharply decreases the strength of zinc single crystals and that the effect of proton irradiation on the deformation process is anisotropic and is much more pronounced when the irradiation is directed along the base plane of the crystals.

F. 1965

38. Chayevskiy, M. I. Effect of impurities on the interaction process between deformed solid metal and molten metals. *Fiziko-khimicheskaya mekhanika materialov*, no. 3, 1965, 343-349.

The effect of low-melting metals sodium, lead, mercury, tin, and lead-tin and lead-bismuth alloys contaminated with oxygen, nitrogen, hydrogen, and carbon on the mechanical and corrosion properties of iron, carbon, and stainless steels is described. The rupture strength of carbon steel at 673°K in pure lead is roughly equal to that in air, but in the lead-tin eutectic it is only half of that in lead. The lead-bismuth eutectic lowers sharply the fatigue strength of carbon steel. The failure occurs on grain boundaries.

39. Chayevskiy, M. I. Thermodynamic activity of aggressive melts as a criterion of the softening effect [on solid metals]. *Fiziko-khimicheskaya mekhanika materialov*, no. 6, 1965, 637-642.

A rule for the determination of the softening action of aggressive melts on solid metal is suggested. If a resulting melt consisting of a solution of an active low-melting metal and a high-melting metal has a negative deviation from the ideal solution, the melt will not soften the solid metal. If, however, the resulting solution has a positive deviation, the melt will soften the solid metal.

40. Chayevskiy, M. I., and V. F. Shatinskiy. Improving the performance of steel operating in low-melting metals by strengthening. *Fiziko-khimicheskaya mekhanika materialov*, no. 6, 1965, 664-669.

Thermomechanical treatment (plastic deformation at 1100°C followed immediately by water quenching) and mechanochemical treatment (plastic deformation at room temperature followed by annealing at 400—600°C) applied to stress concentrators in 1Kh18N9T steel specimens were found to improve greatly the fatigue strength of the steel in air and in lead-tin and lead-bismuth eutectics.

41. Chayevskiy, M. I., V. F. Shatinskiy, and V. V. Popovich. Effect of oxygen in the deterioration of the performance of steel specimens working in contact with molten metals. *Fiziko-khimicheskaya mekhanika materialov*, no. 6, 1965, 654-658.

Results of stress-rupture and fatigue tests with specimens of Armco-iron and 40Kh [AISI-5140], 2Kh13 [AISI-420], and 1Kh18N9T [AISI-321] steels in contact with liquid lead-tin or lead-bismuth eutectics are reviewed. Oxygen was found to increase the negative effect of molten metals, especially that of lead-bismuth eutectic. This effect can be significantly reduced or totally neutralized by preventing oxygen access to the molten metal by alloying molten metals with some additions which increase the affinity of the former with oxygen, or by using molten metals which form protective layers on the steel surface.

42. Den'shchikova, G. I., Yu. V. Goryunov, B. D. Summ, and V. Yu. Traskin. Absorption-induced lowering of the strength of zinc coated locally with a thin layer of mercury. *Fiziko-khimicheskaya mekhanika materialov*, no. 3, 1965, 350-354.

Specimens of commercial zinc plates with a mercury layer applied on limited areas were subjected to tensile tests at room temperature. The obtained data showed that with increasing thickness of coating the zinc strength decreases from 10 kg/mm² without coating to about 2 kg/mm² at a coating thickness corresponding to 0.05 mg/mm². Further increases of the coating thickness have no additional effect.

43. Likhtman, V. I., L. S. Bryukhanova, I. A. Andreyeva, and P. A. Rebinder (Academician). Reduction of surface tension in solid metals by adsorption of atoms of surface-active molten metals. IN: *Akademiya nauk SSSR. Doklady*, v. 160, no. 4, 1965, 867-870.

Thin gallium and lead coating lowers significantly the surface tension of solid zinc at 380°C. A layer of gallium about 10⁻⁵ cm thick lowered the surface tension by 600 erg/cm² in three hours lead, which is much less surface-active than gallium, lowered the surface tension of zinc by 100 erg/cm². The dependence of surface-tension adsorption on the gallium concentration in zinc was determined and the work of adsorption calculated.

44. Mirkin, L. I. X-ray diffraction study of tin recrystallization under the action of liquid gallium. *Fiziko-khimicheskaya mekhanika materialov*, no. 6, 1965, 659-663.

The effect of liquid gallium on single crystals of 99.9% pure tin has been investigated. The investigation confirmed earlier observations that liquid gallium causes a recrystallization of tin single crystals. Under the effect of gallium, small crystals are formed on the single-crystal surface. The intensity of the process increases with increasing temperature.

45. Nikitin, V. I. Nonselective corrosion of alloy steels in liquid low-melting metals. IN: *Akademika nauk SSSR. Izvestiya. Metally*, no. 6, 1965, 153-160.

A 300-hr corrosion test of 1Kh18N9T steel [AISI-321] in liquid tin, bismuth, calcium, sodium, and lithium at 500-700°C showed that liquid bismuth is the most aggressive of all the metals tested. Further tests were carried out with steels EI-612 [AISI-330T], Kh20N12S2 [EI-211], 1Kh18N9T and 15Kh12VMF [AISI-422] in liquid bismuth at 400-700°C for 100 or 300 hr. 1Kh18N9T steel was additionally tested for 400, 800, and 1600 hr. It was found that the corrosive effect of liquid bismuth increased with increasing nickel content in steel. The corrosion rate is reduced in time.

46. Nikitin, V. I. Nature of the effect of liquid sodium contaminated with oxygen on the corrosion behavior of steel. *Fiziko-khimicheskaya mekhanika materialov*, no. 3, 1965, 361-368.

The effect of oxygen in sodium on the corrosion and mechanical properties of Cr-Ni austenitic steel (annealed at 1100°C, water quenched, and aged at 800°C for 10 hr) has been investigated. Corrosion tests were carried out in sodium containing 0.01, 1.0, or 10 wt% oxygen at 700°C for 100, 200, or 500 hr. The specimens tested in sodium with 0.01% oxygen showed no weight change. In all other cases the specimen weight increased. Mechanical properties of steel aged in air or in solution with 0.01% oxygen were the same. The strength and ductility of steel aged in sodium with 1.0 or 10% oxygen were markedly reduced, and a network of cracks was observed on the specimen surfaces. Spectral analysis showed that sodium or sodium oxide did not penetrate into the steel.

47. Nikitin, V. I. Adsorption effect of liquid-metal media on the creep process under compression. *Fiziko-khimicheskaya mekhanika materialov*, no. 5, 1965, 609-611.

The creep behavior in tension or compression of copper tubes $10 \times 0.5 \times 50$ mm filled with liquid bismuth has been studied at 350°C to determine the effect of liquid metal. The test results showed that in both tension and compression the creep rate in bismuth was much higher than that in air. The relative effect of the liquid metal increased with decreasing stress. Under an equal stress, liquid bismuth affected the creep rate in tension much more than that in compression. The creep in tension reached the final stage very rapidly and the specimen failed even under very low stresses. The stronger effect of liquid bismuth on the creep in tension can be explained by the formation and propagation of cracks, whereas in compression-induced creep the deformation proceeds without crack formation. Thus, in compression, liquid metal affects only the process of deformation, while in tension it also accelerates crack formation.

48. Summ, B. D., N. I. Flegontova, and Yu. V. Goryunov. Determination of the diffusion and solubility coefficients of molten metals in polycrystalline metals. *Inzhenerno-fizicheskiy zhurnal*, v. 9, no. 6, 1965, 799-801. TA4.183

Approximate methods are presented for estimating the coefficients and activation energy of the volume diffusion of a molten metal into a solid metal and the solubility of a liquid metal in a solid one.

49. Summ, B. D., L. V. Ivanova, and Yu. V. Goryunov. Effect of metals dissolved in mercury on an adsorption-induced drop of zinc strength. *Fiziko-khimicheskaya mekhanika materialov*, no. 6, 1965, 648-653.

The adsorption-induced lowering of strength of zinc coated locally with binary mercury-base solutions has been investigated. Plates of 99.9% pure zinc with a 18 dan/mm^2 tensile strength were coated with a $3 \mu\text{g}$ mercury or mercury-base solution over an area 2.5×2.0 mm and subjected to tensile tests. At low concentrations, cadmium, gallium, indium, thallium, tin, or bismuth were found to increase the adsorption activity and additionally to reduce the zinc strength

from 7.6 dan/mm² for pure mercury to 5.5—6.3 dan/mm² for mercury solutions. The adsorptive activity, however, markedly decreased at high concentrations of indium or thallium. The length of microcracks in bend tests increased in the presence of gallium, bismuth, lead, indium, or thallium and decreased in the presence of cadmium, tin, and at high concentrations of indium or thallium.

50. Tkachenko, N. N., I. I. Vasilenko, and G. V. Karpenko. Failure of copper alloys tested in solution of mercury salts. *Fiziko-khimicheskaya mekhanika materialov*, no. 3, 1965, 355-360.

The effect of anodic and cathodic polarization at various current densities on time-to-rupture of brass and bronze specimens in mercury-nitrate solutions has been investigated. The cathodic and, particularly, anodic polarization decreased the time-to-failure and sharply reduced tensile strength, ductility, and endurance strength in both types of alloys, but especially in brass.

51. Traskin, V. Yu., Yu. V. Goryunov, G. I. Den'shchikova, and B. D. Summ. Peculiarities of adsorption-induced lowering of the strength of polycrystalline zinc in the presence of gallium. *Fiziko-khimicheskaya mekhanika materialov*, no. 6, 1965, 643-647.

The quantitative relationship between the lowering of zinc strength and the amount of an adsorption-active liquid metal deposited on zinc has been studied. Zinc plates were coated with gallium from a 5% KGaO_2 solution and subjected to tensile strength tests at room temperature at a rate of up to 2 cm/min. The obtained data showed that zinc strength drops with increasing gallium amount per unit of area up to 0.8 dan/mm² at 0.8 mg/mm² of gallium. Further increases of the gallium amount have no additional effect.

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52. Sumin, B. D., L. V. Ivanova, Yu. V. Goryunov, and A. P. Dekartov. Effect of metals dissolved in mercury on the diffusion rate of mercury on a zinc surface. *Fizika metallov i metallovedeniye*, v. 21, no. 1, 1966, 28-32.

The diffusion of pure mercury and mercury-base solutions with Cd, Ga, Pb, Sn, Bi, In, or Tl on a surface of polycrystalline zinc of 99.9% purity has been studied. It was found that at low concentrations, dissolved metal markedly accelerates diffusion, but at high concentrations it decelerates diffusion. The activation energy for the diffusion of solutions of various composition was approximately evaluated.

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